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Understanding the black art of the triple bottom line

Monetizing societal, environmental, and economic impacts leads a Vancouver Island utility to rethink its choice of wastewater treatment solutions

Steve Krugel, Jack Warburton, Ian McKelvey, Reno Fiorante, and Tony Brcic

Communities today place increasing value on improving sustainability, limiting greenhouse gas emissions, and mitigating their impacts on their neighbors. Utility managers, as a result, are being called upon to evaluate potential capital project alternatives using criteria that go well beyond typical financial analysis. Many also are considering a project's environmental and social impacts.

The Achilles' heel of this approach, commonly known as the Triple Bottom Line, has been utilities' inability to compare diverse societal, environmental, and economic impacts and benefits without reverting to qualitative measures that do not reflect their actual values.

Rather, each criterion in a qualitative approach is typically assigned a weighted value and a rating value based on an uncalibrated scale of impact. By multiplying these two values together, utilities arrive at a score for each alternative. But these results can be subjective. Final scores and selections can be unduly influenced by the most vehement voices at the table, as influential participants lobby to assign high scores for criteria or alternatives that concern them, rather than conducting a true quantitative comparison. At times, the process can seem like magic.

The potential for bias in qualitative processes has spurred the development of methodologies that compare project impacts on a more equal basis. Life-cycle assessment approaches, for example, compare diverse environmental impacts using a common unit of measure, such as a disability-adjusted life year, a measure of overall disease

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Aquatic stewards

A Maine WWTP conducts annual release of endangered Atlantic salmon raised at the plant

Since wastewater treatment plays an important role in the sustainability of watersheds, what better way to demonstrate this role than by helping to promote the welfare of endangered local wildlife? For several years, the Bangor (Maine) Wastewater Treatment Plant (WWTP) has released Atlantic salmon raised at its facility.

"I got the idea to do this about 20 years ago," explained Bradley Moore, superintendent of the plant. "I was in Virginia at a wastewater treatment plant down there, and they had an aquarium filled with trout."

Not only was raising fish in treated wastewater a great idea, Moore said, but he thought it also could make a good public relations project. But when he tried to replicate the idea in Bangor with Atlantic salmon, he faced a few obstacles. The plant had to get a permit from the federal government to harvest the fish.

"We had to secure their permission

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Understanding triple bottom line

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burden that is expressed as the number of years lost due to bad health, disability, or early death.

While these types of measures can be useful in comparing impacts within specific categories, they cannot bridge the gap and be universally relevant for all potential economic, environmental, and social impacts. Nor can they be universally understood and used in making practical decisions.

A measure that allows reasonable comparisons among criteria is vital for decision-making. There is arguably only one universally recognized unit of measure that has the potential to bridge that gap: the dollar. With few exceptions, decision-makers have a fundamental and immediate relationship to the dollar or whatever currency is used in their part of the world. Monetizing, or putting a dollar figure on potential impacts, creates a sound basis for making comparisons and assessing the sustainability of multiple alternatives.

Some may argue that economic capital cannot be compared directly to social or environmental capital. Where the impacts of specific criteria differ largely, and the cost of those impacts is high, compared to others, the process requires greater cost scrutiny. In these cases, additional tools, such as life-cycle assessments and more in-depth scientific data gathering, help further substantiate an alternative's value.

Putting it to the test

In 2009, the Capital Regional District — the regional government for the 13 municipalities and three electoral areas on the southern tip of Vancouver Island, British Columbia — used a triple-bottom-line approach when comparing alternative wastewater treatment systems and biosolids management options for its new Core Area Wastewater Treatment Program. This program involves up to three separate new wastewater treatment plants and a new centralized biosolids management facility. The district's board members expressed a strong preference for sustainable solutions and directed staff to compare alternatives using a triple-bottom-line approach.

Project staff elected to monetize the triple-bottom-line impacts and benefits for each criterion, a process designed to provide an equal basis of comparison, including risk considerations. The process of monetizing impacts and benefits for each alternative helped to focus discussions with key stakeholders on the alternatives' value. Where direct costs could not be obtained readily for an individual criterion, surrogate costs and cost factors were used to focus on and ensure a reasonable relative order of magnitude before key stakeholders were given the opportunity to adjust cost values.

Calculating the potential costs

A complete array of economic, environmental, and social criteria initially was developed by a board-commissioned peer review committee from across North America and further refined for specific evaluations by district staff and consultants.

These categories and specific criteria are comprehensive in capturing the effects of implementing a wastewater treatment program and include everything, from capital costs and pollution discharges to property value impacts and odor potential (see Table 1, p. 3). Because the district's decision-makers expressed a strong preference for including resource recovery and other sustainable practices in its program, specific emphasis was placed on including criteria that measure these parameters.

To evaluate the alternatives in each of these categories, a monetary value was determined for each impact. Direct market values could be applied to many criteria, such as capital costs, operation and maintenance costs, site remediation costs, and other factors. For social and environmental criteria that cannot be directly linked to a cost, other surrogate cost factors were used to assess their value, including carbon footprint,

Table 1. Impact categories and criteria used for triple-bottom-line analysis

Economic criteria	Environmental criteria	Social criteria
• Capital costs • Tax revenue implications • Present worth of O&M costs • Flexibility for future treatment process optimization • Expandability for population increases • Flexibility to accommodate future regulation	• Carbon footprint • Heat recovery potential • Biomethane resource recovery • Energy use • Transmission reliability • Site remediation • Pollution discharge • Non-renewable resource consumption • Non-renewable resource generated • Flexibility for future resource recovery • Terrestrial and inter-tidal effects	• Impact on property values • Operations traffic in sensitive areas • Operations noise in sensitive areas • Odor potential • Visual impacts • Construction disruption • Public and stakeholder acceptability • Impacts on future development • Loss of beneficial site uses • Compatibility with designated land use • Cultural resource impacts

O&M = operations and maintenance.

power usage, and nonrenewable resource use:

Carbon footprint. To measure each alternative's carbon footprint, a greenhouse gas inventory analysis of each was performed. By estimating the volume of carbon dioxide equivalents each alternative produced and multiplying that by the current Canadian market value of a tonne of carbon dioxide equivalents, carbon footprint costs were determined. In this case, the options offering the greatest benefits involved using biosolids for cement-kiln fuel or mine reclamation, resulting in carbon sequestration.

Power usage. The net present value for electrical energy consumption was determined for each alternative by evaluating the net power consumption and assuming electricity costs and inflation. The highest or better scores went to waste-to-energy options that involved burning biosolids to produce fuel for power generation.

Nonrenewable resource use. The project alternatives would all consume diesel fuel during construction and in daily operations. The evaluators considered which alternative would be most efficient. Construction-related consumption assumed that a portion of construction costs would be spent on diesel fuel. Operations consumption was estimated using the number of truckloads needed for material and biosolids hauling and the distance hauled, as well as the assumed fuel costs and efficiency. The most efficient of the 11 alternatives was an onsite waste-to-energy option that required no fuel use for offsite trucking.

For impacts without a direct market value, a surrogate was used to capture the essence of the impact, with a preliminary order-of-magnitude value provided for those not typically tied to a dollar amount. Using these parameters, the district could compare social impacts directly to economic impacts based on an equal, common metric. By eliminating subjective, qualitative scoring, order-of-magnitude differences between impacts also could be assessed.

The use of surrogates added some subjectivity to these parameters' costs. Still, the use of a well-understood parameter, such as dollars, provided a meaningful opportunity for key stakeholders to debate and reach consensus on each impact's appropriate order of magnitude. Their discussions touched on everything from the value of a tonne of carbon dioxide equivalent emissions to the cost to a commuter for traffic delays to the impact of potential odor on home values.

Consider pollution discharges. In a perfect world, the true environmental cost of discharging a polluting compound into the environment is known and understood. In the real world, however, these costs rarely are identified and would require in-depth environmental modeling and value assessment to determine.

One way to monetize the cost of pollution is to assess a cost to each unit of discharge, making it possible to compare one alternative to another. When there are only minor variations between alternatives, the cost differences will be minor and only marginally affect decision-making. When larger variations occur, more scrutiny is needed to ensure that differences are meaningful in the context of all potential impacts.

Another method of determining the cost of pollution is to assess the cost of the treatment needed to remove pollutants from the wastestream. Again, in a perfect world, regulators would understand the cost of any particular compound's impacts. When sufficiently severe, regulations would be in place to require treatment for removal to an acceptable level.

Few regulators, however, have that perfect vision. In our world, if a compound is not regulated below an anticipated discharge level, it reasonably can be assumed that the impact of that discharge is less than the cost of removal. On the other hand, if the cost to the environment is large enough, the compound will be regulated, and the incremental cost of removal to the acceptable level is comparable to the cost of the impact at that regulated level.

The perfect regulation, therefore, is one where incremental removal below some level would not accrue benefits to the environment greater than the cost of that incremental removal. Most wastewater evaluations accept this premise, and the benefit of treatment to regulated levels is assumed. The value of the benefit also is not typically included in the evaluation against a "no action" (no treatment) alternative.

The district project team chose the unit-cost method and assessed the unit cost against the discharged wastewater constituents remaining after required treatment. It was not practical to inventory all potentially harmful compounds. Instead, representative compounds were used for the classes of discharged compound. Values used were representative of that class.

In the district's case, the impacts of nitrogen oxide emissions are greater for waste-to-energy alternatives than other options. However, the cost is offset by metal loads in land applications being assessed at a higher cost than ash disposed of in a regulated landfill.

To assess the cost of potential odors from wastewater treatment, the project team counted affected homes and commercial establishments, using satellite photos. Average home values were estimated using community averages. The project team assumed property values would decrease if odor-treatment facilities were not constructed at the plant. This approach enabled the team to assess the relative cost of odor control at different sites, some of which were more remote than others.

This approach also made it possible to estimate the cost of odor mitigation by containment and foul-air treatment. In the district's case, two alternatives were reasonably close in cost, while a third had nearly double the impact. Decision-makers also can use this information to consider a higher level of

Table 2. Example of fully monetized triple-bottom-line analysis results

		Alternative results		
Criteria group	**Criteria categories**	**Alternative A**	**Alternative B**	**Alternative C**
Economic	Capital costs	$255,344,000	$292,986,000	$265,397,000
	Capital costs eligible for grants	--	--	--
	Tax revenue implications	$2,308,318	$2,308,318	$2,308,318
	Present worth of operations and maintenance costs	$243,178,857	$252,843,689	$251,634,251
	Flexibility for future treatment process optimization	$15,360,000	$17,655,021	$15,992,538
	Expandability for population increases	$5,400,000	$3,600,000	$3,600,000
	Flexibility to accommodate future regulations	$1,536,000	$2,648,253	$2,398,881
	Economic subtotal	$532,127,000	$572,041,000	$541,331,000
Environmental	Carbon footprint	-$10,642,627	-$118,495	-$4,343,488
	Heat recovery potential	-$62,680,540	-$62,680,540	-$62,680,540
	Water reuse potential	--	--	--
	Biomethane resource recovery	-$126,191,363	-$122,358,447	-$122,358,447
	Power (energy) usage	$75,019,478	$49,159,836	$56,904,708
	Transmission reliability	$1,579,931	$0	$268,588
	Site remediation	$6,150,240	$6,997,185	$6,376,433
	Pollution discharge	$1,440,654	$1,417,355	$1,417,355
	Nonrenewable resource use	$14,347,108	$5,859,720	$6,894,079
	Nonrenewable resource generated	-$10,671,512	-$10,671,512	-$10,671,512
	Flexibility for future resource recovery	$3,600,000	$3,600,000	$3,600,000
	Terrestrial and inter-tidal effect	$0	$0	$0
	Environmental subtotal	-$107,959,000	-$128,795,000	-$124,593,000
Social	Impact of property values	$0	$0	$100,000
	Operations traffic in sensitive areas	$790,359	$0	$790,359
	Operations noise in sensitive areas	$0	$0	$100,000
	Odor potential	$25,000,000	$25,000,000	$27,500,000
	Visual impacts	$0	$0	$200,000
	Construction disruption	$20,172,176	$23,145,894	$20,966,363
	Public and stakeholder acceptability	$8,011,980	$27,579,243	$24,982,246
	Impacts on future development	$7,542,000	$7,542,000	$20,000,000
	Loss of beneficial site uses	$1,800,000	$1,800,000	$1,800,000
	Compatibility with designated land use	$3,801,857	$4,362,314	$3,951,537
	Cultural resource impacts	$383,016	$439,479	$389,096
	Social subtotal	$67,501,000	$89,869,000	$100,789,000
	TOTAL COST	**$491,669,000**	**$533,115,000**	**$517,527,000**

mitigating treatment for site alternatives with higher impact.

In assessing the impacts of construction, the project team considered, among other things, alternative locations for each potential new wastewater treatment plant. Each one varied in the total length of conveyance pipelines that would have to be installed. The routes those pipes would take also would vary. The team obtained traffic counts along the principal routes the pipes would travel and estimated the duration of the construction period and the cost per minute of delays created by it. One alternative proved clearly more costly than the other two — a cost that could be mitigated through traffic controls, construction scheduling, or other compensatory options.

Other considerations

The district had some latitude in adjusting the direct market values upon which cost calculations were based. The presumed cost of energy, interest rates, or loan term used for the calculation could all affect cost sensitivity. Higher-than-current market rates for power often are assigned in these calculations to motivate green energy production. Inflation rates for nonrenewable resources also can be assigned higher rates than industry projections, which often are based on short-term insight. Engaging elected

Table 3. Example of qualitative triple-bottom-line analysis results

			Alternative results		
Criteria group	**Criteria categories**	**Weight**	**Alternative A**	**Alternative B**	**Alternative C**
Economic	Capital costs	3.33	3	2.5	3
	Capital costs eligible for grants	--	--	--	--
	Tax revenue implications	3.33	3	3	3
	Present worth of operations and maintenance costs	3.33	3	3	3
	Flexibility for future treatment process optimization	3.33	3	3	3
	Expandability for population increases	3.33	2	3	3
	Flexibility to accommodate future regulations	3.33	4	4	4
	Economic subtotal		60	62	63
Environmental	Carbon footprint	1.82	5	3	3
	Heat recovery potential	1.82	4	4	4
	Water reuse potential	--	--	--	--
	Biomethane resource recovery	1.82	5	5	5
	Power (energy) usage	1.82	2	3	3
	Transmission reliability	1.82	2	5	5
	Site remediation	1.82	3	3	3
	Pollution discharge	1.82	3	3	3
	Nonrenewable resource use	1.82	1	3	3
	Nonrenewable resource generated	1.82	3	3	3
	Flexibility for future resource recovery	1.82	3	3	3
	Terrestrial and inter-tidal effect	1.82	5	5	5
	Environmental subtotal		66	73	73
Social	Impact of property values	1.82	5	5	4
	Operations traffic in sensitive areas	1.82	4	5	4
	Operations noise in sensitive areas	1.82	5	5	4
	Odor potential	1.82	3	3	2
	Visual impacts	1.82	5	5	4
	Construction disruption	1.82	3	3	3
	Public and stakeholder acceptability	1.82	4	2	2
	Impacts on future development	1.82	3	3	1
	Loss of beneficial site uses	1.82	3	3	3
	Compatibility with designated land use	1.82	3	3	3
	Cultural resource impacts	1.82	3	3	3
	Social subtotal		75	73	60
	TOTAL COST		**201**	**208**	**196**

officials and community leaders in determining these values can help to ensure that the evaluations reflect community values.

Comparing the numbers

A fully monetized triple-bottom-line analysis for three of the district's 11 biosolids management alternatives is shown in Table 2 (see p. 4). The monetized analysis shows that the overall costs of the project's economic impacts, which were on the order of $500 million, were large compared to the costs of its social and environmental impacts, which were on the order of $100 million.

The district's decision-makers also instructed evaluators to prepare a traditional, nonmonetized analysis and to weigh each category equally. To accomplish this, economic, environmental, and social category weightings were assigned so that all totaled 20 points each. Individual criteria were assigned a qualitative value from 1 to 5, with 5 designating the least impact or greatest benefit. This qualitative weighting and rating analysis approach resulted in a maximum score of 100 points for each category (see Table 3, p. 5).

When the points were tallied and compared, the two methodologies were found to have produced quite different results. These differences were due primarily to the decision to weight each category equally when using the traditional approach, rather than apply a value equal to the total impact and benefit of each category in the monetized approach. The monetization process exerts pressure on the overall value of each alternative relative to its true impact or benefit.

It would be easy to dismiss the values used in the monetized evaluation as inaccurate for nonmonetary criteria, especially when compared to the criteria with direct market values. However, these results show that it is key to provide at least an order-of-magnitude value that can be used as a discussion point when comparing options.

With transparent and reasonable explanations of the assumptions made, key decision-makers can reach a consensus on the relative importance of various impacts. But also there are other benefits to this approach. By placing a value on social and environmental impacts, for example, utilities have another way to evaluate potential mitigation steps. Qualitative scores do not provide utilities with a means to decide what level of mitigation a potential impact might justify.

For example, the district's monetized analysis estimated that, if left untreated, odor issues could have an approximately $25 million potential impact on the community. This dollar amount at least provides the utility with a point of reference when considering appropriate levels of odor mitigation. In other words, mitigation costs far in excess of $25 million may not be justified.

An estimate of an impact's cost also can help justify these mitigation expenditures to ratepayers and funding agencies. In this instance, if odor-mitigation costs are equal to or lower than $25 million, the utility can consider mitigation dollars a great value.

A decision made

By evaluating alternative wastewater and biosolids management options using a monetized triple-bottom-line approach, the district was able to identify the critical impacts and benefits for multiple alternatives. This approach also provided a justifiable basis for sound decisions, making possible an apples-to-apples comparison of potential economic, environmental, and social impacts and benefits. In contrast, traditional qualitative evaluation approaches using criteria weightings and ratings — many based on subjective input — can lead to different conclusions and decisions.

Following this analysis, the district decision-makers have selected their treatment systems, including anaerobic digestion and drying of biosolids for use as a fuel in cement kilns.

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to do this, because the Atlantic salmon are an endangered species," Moore said. But he feels the effort was worth it.

Now, every August, plant staff gathers salmon parr or young salmon, which are about 50 to 75 mm (2 to 3 in.) long. During the winter, the parr are kept in a fish tank onsite that is approximately 681 L (180 gal) and filled with effluent from the Bangor WWTP.

"The fish are taken care of by a team of people," Moore said. The facility's lab director monitors the tank's water quality, and one of the collection staffers, who is an avid fisherman, monitors the fish, he said.

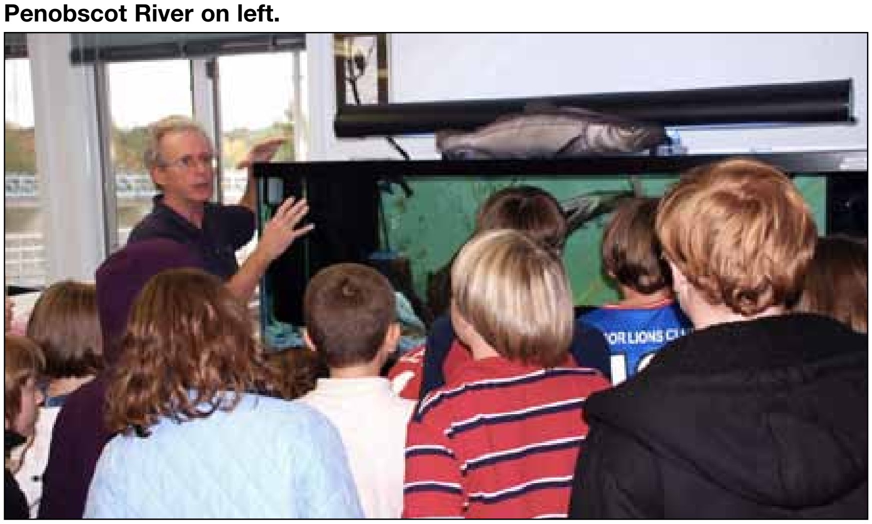
In May, the full-grown salmon are released into the Penobscot River. By then, they are 200 to 250 mm (8 to 10 in.) long.

One year, the WWTP had students from the University of Maine (Orono) tag the salmon before the release.

"We can see if they come back from the Atlantic," Moore said.

City of Bangor

Above is an aerial shot of the Bangor Wastewater Treatment Plant with Penobscot River on left.



P. Steenstra

John Rice, a member of the Bangor wastewater treatment plant staff, addresses students from a local grade school during a tour of the plant.

T. Hambrock

Here is the Bangor Wastewater Treatment Plant's 681 L (180 gal) aquarium with Atlantic salmon parr prior to release to their Penobscot River.

This year, the plant conducted its release in conjunction with the Penobscot Riverkeepers, the neighboring City of Brewer WWTP, and students from John Bapst High School (Bangor).

"[The Bangor WWTP] has been one our partners in these field expeditions with high school students for a while now," said Doug Bean, community coordinator for the Penobscot Riverkeepers.

Moore said the working relationship with the Penobscot Riverkeepers has been positive. "Not that they ever viewed us as polluters, but some environmental organizations do," he explained. "They bring attention to a good cause."

Bean said that this year, because the class size had grown, the Riverkeepers needed to work in coordination with both Bangor and the City of Brewer to conduct the release. Subsequently, 25 students went to the Bangor WWTP, and 25 students went to the Brewer WWTP.

The release day started "very typically" with the students helping to load the 8.5-m (28-ft) canoes in which they would travel, Bean said. "We put a big emphasis on teamwork and basic paddling safety," he said. During the river expedition, the students learn about the logging history of Penobscot River and how the river has evolved environmentally since the passage of the Clean Water Act and Clean Air Act. The students also learn about the river's ecosystem before taking a tour of the WWTP with plant staff. They also release the salmon.

"At the end of the day, we ask the students to tell us what they learned today," Bean said. Some will say they learned proper paddling technique; others talk about cleaning the river, he said.

"After all that, we make the pitch about stewardship," Bean said.

***—LaShell Stratton–Childers**, UE*

On the fast track

An unconventional way of implementing an asset management program saves one utility time and money

Celine Hyer and Ivan Velez

Executing a comprehensive asset management program with traditional planning, design, and implementation phases typically can take between 3 and 5 years and cost millions of dollars. Lee County (Fla.) Utilities (LCU) was determined to implement a comprehensive asset management program to improve the management of its more than $700 million worth of assets, but the utility did not want to wait more than 3 years to see any meaningful results. It also wanted to minimize costs as much as possible. Because of this, LCU, with the help of a consultant, formulated a fast-track approach that would

- complete the planning and design of the program in less than a year;
- focus solely on Waterway Estates, a small portion of its water, wastewater, and reclaimed-water system; and
- enable LCU to fully evaluate the small pilot area in terms of asset condition, criticality, risk, renewal and replacement funding, and potential rate impacts.

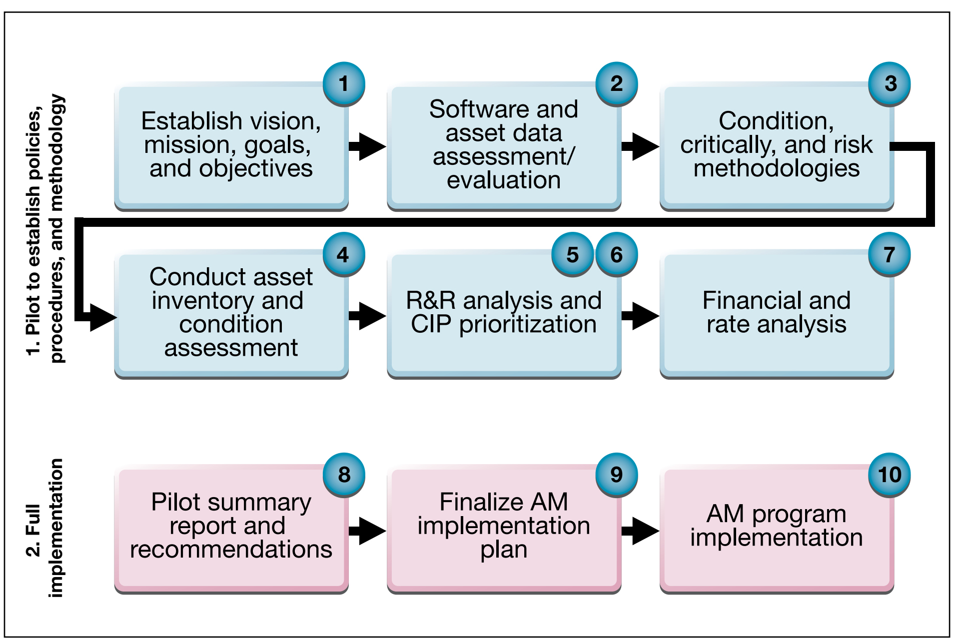
A response to changing needs

LCU is located in Southwest Florida and serves approximately 300,000 customers. The utility has a diverse set of water, wastewater, and reclaimed-water assets, with some purchased from smaller private utilities and some constructed using its own capital program. LCU began implementing a comprehensive asset management program in November 2008. The program was driven by

- the need to do more with less staff due to economic conditions;
- the need to respond to changing emphasis on renewal and replacement projects, rather than infrastructure expansion;
- the lack of a functional computerized maintenance management system (CMMS) and centralized access to data;
- the need to track performance indicators; and
- the need to forecast potential rate impacts due to increased renewal and replacement funding needs.

Because LCU was interested in seeing the benefits of the program quickly and spending its dollars wisely, the utility went with a “pilot approach” instead of a traditional approach (see Figure, below). This required establishing an asset management methodology and framework, as well as performing a full asset condition and risk assessment for a small portion of the service area. Because of this, LCU staff was able to see how the established methodologies would work, as well as the results and benefits of implementing the program, before it was applied to the entire system.

Pilot project approach methodology



R&R = renewal and replacement. CIP = capital improvement project. AM = asset management.

Establishing the framework

The first step in the implementation process began with establishing the framework for the rest of the program. The framework included the overall mission, vision, and goals for the project.

LCU conducted a 1-day workshop to establish goals for the project that aligned with its existing strategic plans and focused on the strengths, weaknesses, and opportunities that the utility faced. The discussion was focused on typical elements of an asset management program, such as overall strategy, defined organizational roles and responsibilities, defined levels of services, adequate information technology and business support systems, and formal infrastructure and financial planning. But elements unique to LCU, such as its existing staff capabilities, the ability to hire or define staff roles, financial constraints, and board priorities and support, were also considered. At the end of the workshop, a draft mission and vision statement was created, as well as a set of goals that would be accomplished during the next 4 years to fully implement a comprehensive asset management program. Some of the initial priorities were related to asset information and performance measures.

Another important step was an evaluation of LCU as an organization from the perspective of how the utility would be able to support an asset management program once it was implemented. This evaluation was conducted through a series of interviews with senior LCU staff to understand how things were done currently in terms of work and asset management. The interviews also were conducted to assess what additional resources or roles and responsibilities would be required for the improved processes. Adding positions really was not an option, but expanding or changing job duties and creating committees were suggested approaches. Fortunately, LCU already had designated an asset manager position to manage the project and chair the committees, as necessary. Committees were established for the areas of strategic planning, asset management planning and standards, infrastructure planning, and information technology/business systems planning.

LCU also conducted an analysis of the IT systems that supported work and asset management. The focus of the analysis was the utility's geographic information system (GIS) and the two (CMMS) programs it was running at the time. The utility discovered that the GIS was populated with good-quality data that covered most of LCU's pipe assets. However, the existing CMMS programs did not keep an inventory of the majority of the assets, work orders were not being written, and costs were not being accounted to the assets themselves. In addition, neither CMMS system could perform comprehensive asset management program functions, nor could they interface with the GIS to create a centralized asset inventory. Because of this, it was recommended that LCU procure new software.

Establishing a methodology

The second step in the implementation process focused on workshops with the LCU staff to determine the methodology for the asset risk management. Industry standard documents, such as the 2006 *International Infrastructure Management Manual* from the New Zealand Asset Management Support (Wellington, New Zealand) and the 2001 *Sewerage Rehabilitation Manual* from the Water Research Centre (Swindon, England), were presented and customized to meet LCU's needs. The main workshops focused on topics regarding both vertical (plant, lift stations, etc.) and horizontal (pipes, valves, etc.) assets, specifically establishing an asset hierarchy, and establishing asset attributes for collection, asset physical condition evaluation, asset criticality evaluation, and asset risk assessment. The result of the workshops consisted of guide documents that detailed how assessments would be made. The documents also ensured that future assessments could be performed by LCU staff, and scoring would be consistent.

Collecting data, determining results

The Waterway Estates system, which represented approximately 5% of the overall system, was chosen for LCU's pilot, because it contains representative water, wastewater, and reclaimed-water-plant and -pipe assets that are a variety of ages. This was critical to being able to extrapolate results for the rest of the system.

To obtain the asset inventory and condition data, LCU conducted field visual condition assessments of Waterway Estates' aboveground assets, zoom-camera inspections of gravity pipes and manholes, and a pipe reliability study to ascertain pressure-pipe conditions. Interviews and document reviews were performed to determine asset criticality for the aboveground assets. GIS was used to assign criticality for the pipe assets. All data were collected and calculated. This was later stored in an inventory condition assessment access database for loading into a future CMMS.

LCU held a final results review workshop that showed the detailed outcomes — such as the individual asset condition, criticality, and risk scores, and renewal and replacement needs for the next 30 years — based on the established methodologies, and enabled the project team to see the effects of their decisions. Some minor changes were identified regarding the pipe criticality definitions that were made for the final guide documents.

The data collected also included replacement costs, remaining useful life, and asset risk scores. This was used to create a renewal and replacement capital improvement program (CIP) for the Waterway Estates area. Business case templates were created to assist in gathering information needed to prioritize projects and place them in the appropriate timeframe within the CIP. The templates and prioritization helped simplify funding decisions and enable the right projects to be completed first.

The overall pilot-project schedule was coordinated with LCU's budget and rate cycle so that results could be incorporated into the fiscal year 2010 CIP update and rate resolution update. An extrapolation of the Waterway Estates results showed that a rate increase to support additional renewal and replacement soon was needed.

Moving forward

Implementing an asset management program using a pilot project, rather than a more traditional approach, proved successful for LCU. Phase 1 of the project was completed on schedule within 10 months, and it included an asset management plan document to serve as a road map for LCU to conduct a full implementation. It also included all of the methodology guides and procedures that were established during workshops so that the program can be sustainable and ultimately carried on by LCU staff.

The original pilot data proved that a rate increase was needed and showed the usefulness of gathering comprehensive asset condition, criticality, and risk data. During Phase 2, funding was approved to continue implementing the program. This phase also includes the procurement and implementation of a new CMMS package, as well as the continued condition, criticality, and risk assessment of the rest of the vertical assets.

By performing a fast-track asset management project, any utility can cost-effectively get quick results to present to its board for support and funding of the rest of an asset management program implementation, and the utility can have a full understanding of the planning and design decisions that are made and how those decisions may affect overall program implementation. In addition, CIP, renewal, and replacement needs identified within the pilot area could be a good indicator of what unfunded needs may exist throughout the utility. In the case of LCU, it provided the utility director and board with a rough idea of what impacts were in store prior to completing the entire asset management program while also demonstrating the overall program value. Finally, the comprehensive asset data collected from the pilot area also enabled LCU to effectively evaluate and select new asset management software and has assisted in the configuration of the software during Phase 2. Currently, LCU is using successfully a new CMMS package for work and asset management for its vertical assets, with the linear assets to be included by the end of the year in a second implementation phase. All data collected during the pilot are now part of the CMMS to support the asset inventory, as well as reporting.

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Exploring new options

San Diego breaks ground on a facility that converts advanced treated wastewater into drinking water

In the arid southwestern United States, water can come at a premium, but many municipalities have developed ways to combat water scarcity. Some have imposed stringent water restrictions, while others are importing water from other areas for additional supply. Some are using desalination plants to purify brackish water, while others — such as San Diego — are more aggressively pursuing water reuse. The San Diego Public Utilities Department is conducting an advanced water-purification demonstration project that it hopes will lead to something more permanent. Eventually, the city hopes to increase its water recycling by infusing reservoir water with advanced treated wastewater — both of which would be treated at a drinking water facility before being sent to customers' taps.

The demonstration project, slated to be complete by early 2013, represents the second phase in the city's evaluation of water-recycling methods, according to a utility fact sheet. The first phase was a 2005 water reuse study that identified reservoir augmentation as the preferred option for developing recycled-water sources, the fact sheet states. In addition to the demonstration project, the utility is conducting a study of the San Vicente Reservoir to "test the key functions of reservoir augmentation and to determine the viability of a full-scale project."

Taking matters into their own hands

San Diego began construction of its advanced water-purification demonstration project this year. It is projected to cost $11.8 million, said Marsi Steirer, the utility's deputy director of Long-Range Planning and Water Resources. Steirer said the project was funded partially by grants from the State of California and the U.S. Department of the Interior's Bureau of Reclamation. The city also increased water rates temporarily to raise funds. The water rate increase "started in Jan. 1, 2009, and it was removed around Sept. 1, 2010," Steirer said.

San Diego has taken previous forays into water reuse. It has two reclamation facilities: the North City Water Reclamation Plant, which has a treatment capacity of 114,000 m^3/d (30 mgd), and the South Bay Water Reclamation Plant, which has a treatment capacity of 57,000 m^3/d (15 mgd).

"But [the] majority of the recycled water that we treat at our facilities is used for landscape irrigation," Steirer said. "We don't have large industrial customers or any type of processing. There are customers who use it for urinals and flushing, as well as cooling towers, but 98% of it is used for irrigation."

San Diego never has used reclaimed water as drinking water, but it faces the same water scarcity issues that many other utilities face in its region.

"We have limited local water resources," Steirer said. "We import from Northern California and the Colorado River 85% to 90% of our water. We just came out of a multiyear drought in California." She said that San Diego recently lifted mandatory water restrictions for outdoor use, and its imported water from Northern California faces similar restrictions.

"If you want to take matters into your own hands, you create a source of local supply," Steirer said.

Although residents in other parts of the country have rejected the type of water reuse San Diego wants to employ, local customers did not object to the utility's plans, Steirer said. Through polling, the city knew in advance that the public's acceptance of recycled water later used as drinking water had continued to increase over the years. The city also has been

San Diego Public Utilities Department

The reverse osmosis equipment at the San Diego Advanced Water Purification Facility, which is located at the City's North City Water Reclamation Plant.

engaged in an extensive public outreach program and has promoted stakeholder involvement.

Steirer said in addition to sending representatives to community groups and service clubs, "we're trying to do various community events," she said. The department has multicultural consultants that are going into the local communities to explain the project, and they have translated informational materials into different languages.

"We think it's really important for people to know and be educated," Steirer said.

Testing and gathering data

As part of the demonstration project, the 3785-m^3/d (1-mgd) Advanced Water Purification Facility receives treated wastewater from the North City Water Reclamation Plant, where the wastewater already has gone through secondary and tertiary treatment, except for disinfection with chlorine, Steirer explained. At the purification facility, the effluent then is separated into two treatment trains with different types of membrane filtration — microfiltration and ultrafiltration. Here, organic materials and salts are dissolved.

"Ultrafiltration, which has the smaller pores, is the bigger energy user," Steirer explained. "But we're testing them [both] to see which one does the better job in treating the water."

After the membrane filtration, the effluent undergoes reverse osmosis. After reverse osmosis, it goes through a third barrier of ultraviolet disinfection and advanced oxidation with hydrogen peroxide. For now, none of the purified water is being sent to the reservoir, but site visitors can see the water pouring out of a faucet into a lab beaker, Steirer said. "We hold up this lab beaker of advanced recycled water. It's pretty clear, and it shows [that the treatment process] is pretty effective," she said.

Steirer said the goal of the project is to gather performance data on individual pieces of equipment, specifically how well the equipment is at removing and destroying contaminants. In addition, the utility is collecting operations and maintenance data for each


San Diego Public Utilities Department

This faucet, from which purified water flows, is the finale of the visitors' tour at the advanced water purification facility. The water began as tertiary treated effluent and has gone through membrane filtration, reverse osmosis, and advanced oxidation using ultraviolet light and hydrogen peroxide at the facility.

process, such as the cost of chemicals used and energy consumption. All the units are metered individually.

"It's really helpful, because a lot of times the question we get is, 'Well, if you proceed to full-scale, what will be the cost?'" Steirer said.

Steirer said that with all of these data, the utility should be able to provide a good estimate in its final report of what the cost of a full-scale operation will be.

The next step

At the conclusion of the project, the utility will present its findings to the mayor and city council, which eventually will vote on whether to take the project from demonstration to full scale. The project and its findings are being monitored by regulators.

According to the fact sheet, throughout the process, an advisory panel of experts has provided oversight to determine if the purification process satisfies all water quality, safety, and regulatory requirements of the California Department of Public Health. The panel also is monitoring what will happen once the recycled water is added to the reservoir.

The utility and regulators are trying to determine how this water reuse should be regulated. Although California has had groundwater regulations on the books for more than 15 years, the state "has no regulations for surface water augmentation, so we're working with the regulators to identify the pathway to regulate a full-scale project," Steirer said.

***—LaShell Stratton–Childers**, UE*

How to tap a utility's human infrastructure

To cost-effectively improve performance and capacity benefits, the City of Guelph, Ontario, undertook an optimization program with human infrastructure at its core

Gerard P. Wheeler, Cameron D. Walsh, and Bob A. Hegg

Municipalities facing a multiplicity of emerging challenges, especially during downturns in the economy, need cost-effective utility-management strategies. Organizational excellence, founded on authentic relationships and applying effective management solutions, can significantly improve performance and capacity benefits.

The Guelph wastewater treatment plant is located on the Grand River Watershed in southwestern Ontario.

Due to the relatively small capacity of the receiver, the facility is required to achieve stringent effluent quality. Balancing development pressures while maintaining the stringent discharge requirements prompted the city to initiate a comprehensive optimization program aimed at cost-effectively maximizing the facility's performance and capacity.

A performance evaluation of the plant showed considerable untapped capacity in the existing unit processes. It indicated that, while the facility was rated at 64 million L/d, the major unit processes had the potential to treat flow rate exceeding this value. But the evaluation also identified significant human infrastructure developmental limitations that had to be resolved first. For example, staff members did not have the authority to make the required operations adjustments to establish an optimum level of process control and performance from the existing unit processes.

The city's optimization program unfolded in two major stages:

- developing the physical infrastructure to support modifications to enable better application of the human infrastructure, and
- maximizing the effectiveness of the existing physical infrastructure through problem-solving skills development. (This second stage includes the use of several basic tools and approaches.)

Putting people in a position to be successful via shared problem-solving was crucial to the acceptance and sustainability of the optimization program. The problem-solving platform was used to develop personal and professional relationships so that sharing technical information and implementing shared ideas became automatic. An offshoot of this approach is the subtle development of leadership and management skills. Initially, the City of Guelph's management tentatively supported the optimization efforts. As successes were demonstrated, they began to fully and unreservedly support these efforts.

Completed topic development sheet

Topic or issue: Deteriorated nitrification rate in four secondary unit processes.	
Benefits of addressing topic or issue: The nitrification efficiency that had been previously achieved in the secondary unit processes will be re-established.	
Possible obstacles or factors: • Inconsistent process control was limiting nitrification efficiency. • Inadequate communications.	**Possible solutions:** • Re-emphasize importance of achieving consistent process control to support nitrification. • Establish improved communication and sharing of information among operations staff.

Action items

N	Action item	Who	When
1	Implement daily operator-in-charge meetings.	Facilitator	May 6th 2009
2	Participate in daily meetings.	Operations supervisor	May 6th 2009

N = number.

The tools

Process-control procedures. The application of activated sludge for wastewater treatment is a long-established technology, and the equipment is well-advanced. But multiple studies across North America have documented that even newly constructed treatment plants often achieve less than optimal performance from their unit processes. Although in this case, the City of Guelph made changes to its unit process operations, a detailed description of these changes is beyond the scope of this article.

Topic development sheets. In addition, a topic development sheet is a powerful tool that can be used to address institutional barriers limiting the city's capability to achieve optimum performance. It includes spaces to outline the issue, benefits, possible obstacles, and possible solutions (see table, above). Although it is a simple sheet, it streamlines many leadership and management concepts that can be used to clearly define, isolate, and overcome obstacles to change.

Once a topic is chosen for development, such as collecting additional process-control data, users typically begin to list obstacles. Often, this is where progress stops. The sheet encourages the user to identify potential solutions but, more importantly, requires him or her to identify specific action steps for follow-up, typically by the individual who reported the obstacle in the first place. This sheet has helped encourage actions that previously were not pursued. It encourages the user to focus on solutions, rather than becoming frustrated by real or perceived obstacles.

Special studies. When obstacles are substantial or complex, a special study may be applied after a topic development sheet is completed. This study requires a systematic and documented approach to obtain the data necessary to make good decisions. The study format is based on the scientific method, and it guides the user through the hypothesis, approach, duration, expected results, actual results, conclusion, and recommendation.

The format encourages users to hypothesize about what may be causing a problem and then methodically develop the steps to prove or disprove the hypothesis. A study often spawns other studies when multiple variables negatively affect the treatment plant's performance. Brevity is encouraged, which requires a disciplined thought process when drafting the study. The advantage of a common template to document studies is that multiple staff can use the same format. This facilitates better communication, because staff are enabled to "attack the problem" in a synergistic manner, rather than attack each other. Also, documenting the results establishes the information to support data-based decision-making, justifying new and revised operating procedures.

Both the topic development sheet and the special study encourage inquisitiveness, research, and communications. They also boost the staff's confidence level.

Quarterly meetings. The city needed to create an environment in which staff could successfully use the topic development and special study tools. The city initiated a quarterly strategic planning meeting to manage the optimization program and the multifaceted influences and challenges to implementation. Change management is challenging, and it requires tenacity to stay the course, particularly during the early phases of the optimization program.

An implementation support team was established to maintain a continuous focus on achieving the program objectives. It was composed of senior management staff from the city and supported by an external facilitator with extensive expertise in developing and implementing similar programs with the U.S. Environmental Protection Agency. The team's role is to routinely assess and adjust project activities and direction to ensure that institutional barriers do not impede progress. Dedicated time is scheduled for these quarterly meetings to ensure that team members can focus on the planning process. Typically, planning meetings require 3 to 4 days to complete, and they include provisions for developing a comprehensive list of action items to be completed by designated individuals during the upcoming quarter.

These meetings provide continuity for the program, encourage assignments to be completed, support positive peer pressure among participants, and increase participants' comfort level with the process. The meetings provide a forum to exchange ideas, develop synergy among all participants, and allow meaningful feedback from senior management.

Nominal group-process tool. This formal process enables a group with diverse opinions and approaches to identify, clarify, and prioritize topics for discussion. Topics are discussed, notes are taken, an approach is identified, and steps are adopted by all participants to keep optimization efforts moving forward. This process is self-correcting and enables project activities to remain current. Participants can bring up ongoing topics or current issues of concern. Each member participates equally in this process, regardless of hierarchy, age, or length of service.

Once the issues are listed, all parties prioritize their topics for discussion by voting (for example, five votes would be assigned for each participant's highest-priority topic, and four for the second-highest). Topics are ranked, first, on the number of people voting for them, and second, by the number of votes received. This technique teaches each team member that his or her priorities may not be the larger group's priorities. It builds consensus on the most pressing issues facing the organization. Frequently, the topics nominated by the planning team are a combination of technical and nontechnical issues.

There is a learning curve associated with both strategic planning and following the nominal group process, as well as a trust factor among participants that must be established. It may take at least a year for the group to be fully functional, and it may be best to have a facilitator participate in the initial meeting while participants get used to the openness of discussion.

Data-management tool. Easy access to data is a prerequisite for effective data-based decision-making. Historically, staff became frustrated by their inability to easily access data and plant records. The Guelph utility consists of four activated sludge systems, each composed of east and west liquid trains. Effectively, eight independent liquid trains had to be managed. The generation, storage, and retrieval of data were inconsistent from plant to plant, rendering access to files tedious and time consuming.

Faced with this logistical hurdle, operations staff avoided the work of trying to look at the data. Consequently, vast amounts of valuable data were not processed or interpreted by operations staff with any degree of regularity. Understanding that the fundamental approach to process control was to encourage data-based decision-making, the old method of data management and storage clearly was inadequate. A new data-management tool that truly supported operations staff was required. Utility management responded by supporting the development and implementation of a purpose-built data management program using Microsoft Excel.

The program was designed on the "enter once" concept, meaning data are entered once each day into 20 databases by several operations and laboratory staff members working at separate terminals. The program is composed of macros that summarize the data saved in the databases and update process-control trend charts for each of the primary, secondary, and tertiary liquid trains. This approach relieved the operator from the tedium of repetitive data entry.

Data are processed and summarized and, most importantly, used daily. Staff are freed up to focus entirely on data interpretation. The tool revolutionized staff's data interpretation skills, enabling them to focus on applying the concepts of process control of activated sludge. A similar approach to data management for biosolids stabilization and treatment completed the purpose-built, facilitywide data-management tool.

Minor modifications toolbox. When applying optimization, several minor design limitations will inevitably emerge. Resolving these limitations or finding ways to operate around them are fundamental parts of the optimization effort.

One example of a minor modification is poor flow-splitting. Not every facility may understand the negative impact that poor flow-splitting can have on process control and even performance. At Guelph, it was discovered that the levels of the effluent weirs in several primary clarifiers were uneven, causing different flow rates among the four facilities. The imbalance was causing two distinct loading patterns within each 24-hour period. Once rectified by either relocating or replacing the primary effluent weirs, the operations staff's ability to achieve effective process control of both the primary and secondary unit processes significantly improved.

The city then purchased a set of transportable velocity meters to enable routine checks of flow splitting across the facility. Flow-splitting control and expertise have been incorporated to support the ongoing optimization activities, and these devices proved invaluable in resolving a previously unknown flow-split imbalance between two clarifiers.

Optimization program facilitator. After a year or so of development, it became apparent that efforts to support human infrastructure development were not being accomplished in a timely manner, despite the implementation-support-team members' focus. The optimization program included three key multifaceted components: address the facility's performance limitations, tap the latent capacity of the existing physical infrastructure, and establish a sustainable human infrastructure that would endure. The first two components were more straightforward to manage and implement than the third.

Management staff elected to hire a dedicated optimization program facilitator, specifically to manage the numerous human infrastructure development activities and to maintain an atmosphere conducive to change. The city recognized that solutions developed for both technical and management challenges had to be founded on skills transfer; otherwise, sustainability would be compromised. In this context, the program facilitator's role was focused not on solving problems directly but on developing situations that enabled people to succeed personally while collectively solving technical and nontechnical problems.

The facilitator was expected to quietly — but persistently — push the organization to systematically resolve operationally controllable issues while simultaneously tapping the capacity of the existing physical infrastructure. The program facilitator was to use the basic implementation tools described above to encourage others to develop problem-solving skills and, thus, enhance their own leadership and management skills to better support the facility's capability and performance.

The optimization program included three key multifaceted components: address the facility's performance limitations, tap the latent capacity of the existing physical infrastructure, and establish a sustainable human infrastructure that would endure.

Implementation

A few examples help explain how the city used these tools to make improvements.

Empowering an operations supervisor. The prospect of significantly altering or abandoning old customs can be daunting, and this is a natural response. The supervisor of operations felt pressured by the pace of change and the new direction. He also was concerned about not fulfilling his obligations as a member of the implementation support team. The program facilitator had to help resolve issues and demonstrate the supervisor's revised role. The supervisor was concerned about the simultaneous deterioration in the rate of nitrification in all four aeration systems at the facility. The tool used to respond to this issue was the topic development sheet.

In April and May 2009, there was a noticeable deterioration in secondary effluent ammonia quality in all aeration systems in service. A review of the operating data revealed that the level of process control was not consistent in each facility, and the level of communication among the operations staff was not ideal. After implementing daily operator-in-charge meetings, the trend in deteriorated quality reversed in all four systems.

The major learning steps for the supervisor were to create the environment for the operators to implement the new approach without assuming responsibility for having the answer and to provide direction to the operators at the meeting. This way, the supervisor has ample time to observe the new process-control procedures and judge their effectiveness.

Improving problem-solving skills. Residual chlorine removal using sodium bisulfite following disinfection is required at the facility. Before optimization, operating data indicated that staff could not control the existing quenching equipment accurately enough to achieve the low chlorine residual limit that was required. Consequently, ultraviolet disinfection was considered a necessary alternative technology to chlorine, with a high capital cost.

The city used a special study to evaluate the capacity of the existing chlorine-quenching system. One operator was designated lead investigator for the study. Process-control adjustments resulted in a marked reduction in both the residual chlorine concentration and the variability, but the residual concentration remained above the limit several months after the study was initiated. Following further refinements to the control of the quenching system, the stringent limit was eventually achieved.

This new level of performance with the existing physical infrastructure was unprecedented. The same staff members who had not achieved the desired level of performance before are consistently achieving the limit today. The difference is improved problem-solving capability to tap the existing potential.

The special study format provided the methodology and the mechanism to develop data and make data-based decisions that eventually resulted in the progressive improvement. Using the study results, the operator was able to train other operators, lay the groundwork for the new way of doing business, and avoid the cost of new ultraviolet disinfection.

Using a data-management tool. A feature of establishing consistent process control, supported by effective data management, is that cause-and-effect relationships are clearly detectable. One of these relationships became apparent when wastewater production at an industry facility in the city resulted in reduced nitrification efficiency at the treatment plant.

Treated effluent ammonia concentrations went above 20 mg/L, which signals a virtual shutdown of nitrification in the secondary unit processes, since the influent and final effluent ammonia concentrations were virtually identical. Further investigation by the operations staff during the daily operator-in-charge meetings confirmed that the ammonia concentration had increased abruptly and simultaneously in all aeration systems.

The loss of nitrification was serious, and it prompted a full-scale investigation for potential outside sources capable of having such a negative impact on the process. Staff were justified in investigating outside sources, because the level of process control at the facility was unchanged, and the increase in ammonia concentration had occurred simultaneously in all five aeration systems, including the final effluent. The trend charts featured in the data-management tool enabled staff to quickly and accurately isolate and confirm the source of the problem.

Subsequent studies confirmed that the cause was actually inhibition and not nitrogen overload. The source of this material was an industry facility in the city. At subsequent briefings with industry officials, plant staff used the same data-management tool to clearly illustrate the cause-and-effect relationship and to justify why they could confidently conclude that the source of the nitrification-inhibiting material originated outside the treatment plant.

Applying the data-management tool to confirm that the source of inhibition was outside the plant gave the staff confidence to provide leadership. This approach avoided the typical “victim response” that often arises from such episodes. In fact, industry officials later applied the same data-based approach to addressing the source of inhibition within their own facility.

The impact

The experience gained from understanding how the multiple limitations to optimized performance were systematically identified and resolved greatly increased the operations staff’s confidence. Staff members were adequately supported and successful, and they understood the fundamentals of process control — and applied them on a daily basis. Led by the program facilitator, staff members were able to take on the significantly more robust challenge of demonstrating the existing physical infrastructure’s full capacity while maintaining a new level of secondary effluent quality. While the technical and financial benefits derived from developing leadership and management skills are impressive, it is the growth in human infrastructure capability that has been most inspiring. Practice and repetitive application of the tools are fundamental to a learning organization. Learning increases confidence, whereby staff eventually become self-motivated.

The City of Guelph’s program also is being expanded beyond its facility. The Ontario Ministry of the Environment has funded an areawide program founded entirely on both leadership/management skills development and applied problem solving. The operations skills and knowledge developed and applied at Guelph will be transferred to other utilities in the Grand River Watershed, sponsored by the Grand River Conservation Authority.

For management staff within the city, having access to reliable data that originate from the application of these simple tools enables effective decision-making. Eventually, these benefits will permeate multiple levels of the organization and influence strategic decision-making.

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